IMPACT TEST SIMULATION WITH DIFFERENT IMPACT DIRECTION USING FEA FOR BUMPER CAR

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Mechanical Engineering

(Structure and Material) (Hons.)

By

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DECLARATION

I hereby, declared this report entitled “Impact Test Simulation with Different Impact Direction Using FEA for Bumper Car” is the results of my own research except as cited in references.

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Author’s Name : MUHAMMAD NABEL BIN ZAKARIA

Date : ……...

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APPROVAL

This report is submitted to the Faculty of Mechanical Engineering of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering (Structure and Material) (Hons.). The member of the supervisory is as follow:

…….

(DR. MOHD BASRI BIN ALI)

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DEDICATION

To my beloved mother, Mashitah bt Mohd Yusop and my family who always there by my side during this whole Final Year Project duration.

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ABSTRACT

Impact is the action of one object coming forcibly into contact with another. In term of vehicles, there are different point of impact on the car such as frontal, side and rear but the most severe crash happens from the frontal impact and then from side impact**.** Bumper is one of necessary part in passenger vehicle as it is the main tool to damp the energy from crashes**.** Therefore, this study was carried out to investigate how energy absorbed for the front bumper from different angle of impact**s** 0˚, 30˚, 45˚ using Finite Element Analysis (FEA). The velocity 80 km/hr is identified for the impactor and not to change through the analysis. For the material and design of the bumper it is decided to be a metal bumper as the beginning stage before studying the real material with the design of a GEN 2 front bumper. During the simulation, the meshing used is the tetrahedral type with the element size of 30 mm for all mesh in bumper and impactor. The results showed that the amount of energy absorption increase while the amount of the displacement decrease with the increase of impact angles.

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ABSTRAK

Impak adalah perbuatan di mana satu badan menghentam satu badan lain secara paksaaan. Bagi kenderaan, ada beberapa titik impak di mana selalu terjadinya kemalangan seperti bahagian depan, bahagian sisi dan bahagian belakang tetapi impak yang paling teruk adalah pada depan dan sisi. Bumper adalah salah satu komponen penting pada kenderaan untuk menyerap impak daripada kemalangan. Oleh itu, kajian ini telah dijalankan untuk memahami bagaimana penyerapan tenaga pada bumper hadapan untuk sudut impak yang berbeza iaitu 0˚, 30˚, 45˚ menggunakan Finite Element Analysis (FEA). Kelajuan untuk impaktor telah ditetapkan pada 80 km/j dan tidak berubah sepanjang analisis. Bagi bahan dan rekabentuk untuk bumper pula telah ditentukan menggunakan bumper logam sebagai permulaan sebelum menggunakan bahan sebenar, bumper ini juga mengambil rekabentuk daripada bumper hadapan kereta GEN2. Keputusan akhir menunjukkan jumlah tenaga yang diserap bertambah manakala jumlah perubahan kedudukan berkurang apabila sudut impak bertambah.

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LIST OF ABBEREVATIONS

NCAP	New Car Assessment Programme
FMVSS	Federal Motor Vehicle Safety Standards
FEA	Finite Element Analysis

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LIST OF SYMBOLS

°	=	angle
s	=	seconds
J	=	Joules
mm	=	millimeter
N	=	Newton
E_A	=	energy absorption
F	=	force
U	=	displacement
%	=	percentage
km	=	kilometre
h	=	hour
m	=	mass
v	=	velocity
e	=	coefficient of restitution
δ_{max}	=	maximum deflection
K_{eq}	=	equivalent stiffness

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CHAPTER 1

INTRODUCTION

1.1 Background

Impact is the action of one object coming forcibly into contact with another or can also be called collision or crash. In term of registered vehicles, passenger vehicles are 90% from the total number. In 2009, rough calculations showed that 9,640,000 vehicles were reported crashed and 95% from these crashes involved passenger vehicles (Davoodi et al., 2012). With every crash, there are different point of impact on the car such as frontal, side and rear. In addition, each of them has their own severity towards the passengers. However, the most severe crash happens from the frontal impact and then from side impact. Figure 1.1 shows the presentation of data from Volvo's accident data base (Cheon, Choi, & Lee, 1995; Donga, 2011).

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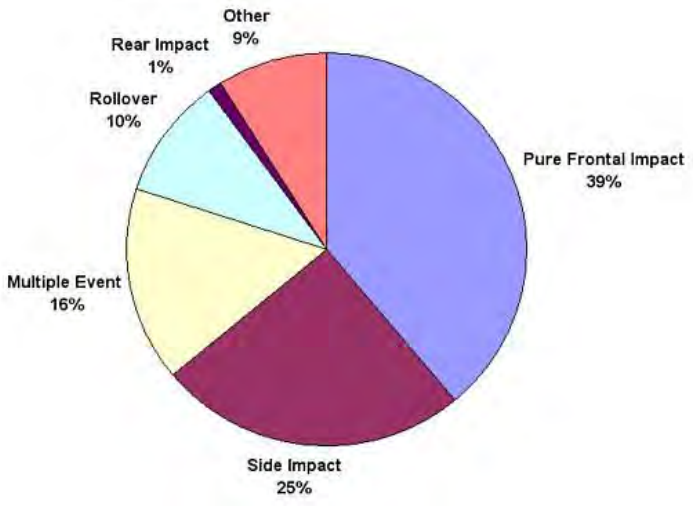

Figure 1.1: Volvo's distribution of serious-to-fatal crashes (Donga, 2011).

There are many tries to lessen the effect from the frontal impact crashes using air bags and energy absorption bumper.(Cheon et al., 1995). Bumper is one of necessary part in passenger vehicle as it is the main tool to damp the energy from crashes and also protect others of vehicle such as lamps, hood and cooling system especially the front bumper (Dange, Buktar, & Raykar, 2015; Davoodi et al., 2011). The bumper system consists three main parts: fascia, energy absorber, and bumper beam as shown in Figure 1.2 (Davoodi et al., 2011, 2012).

The Oblique Moving Deformable (MDB) Test as shown in Figure 1.3 below is expected to represent serious oblique real world crashes notable frontal engagement with significant intrusion and is intended to represent an oblique vehicle to vehicle crash with each vehicle advancing at 50-60 km/h or with one vehicle advancing at 100-120 km/h (Hollowell, Gabler, Stuckl, Summers, & Hackney, 1999).

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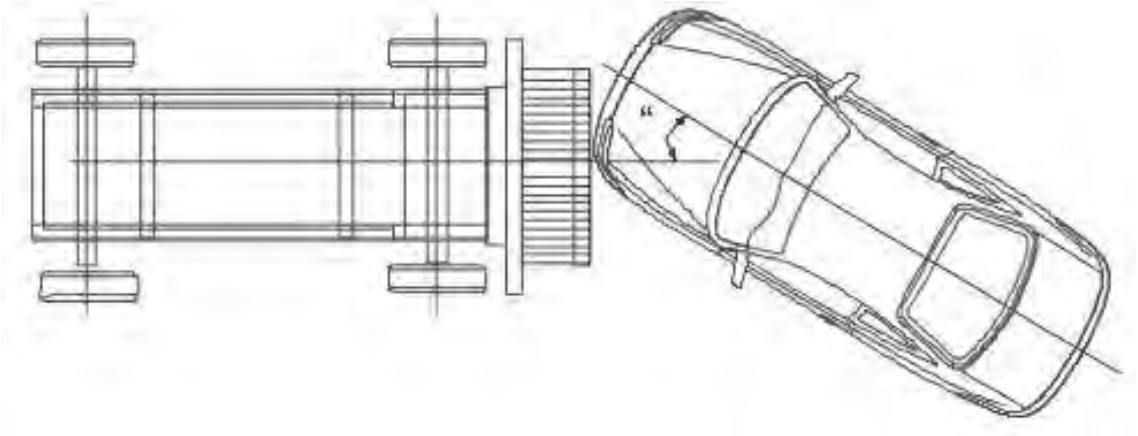

Figure 1.2: Oblique Moving Deformable (MDB) Test (Hollowell et al., 1999).

Studies also showed that critical penetration energy increase as the curvature increase, impact angle increase and interface increase (Yang, Cho, Im, Cha, & Kim, 2006) and oblique angle is a crucial factor not only on the penetration resistance of the target plate but also on its deformation/failure modes (Ni, Jin, & Lu, 2014).

1.2 Problem Statement

Studies shows that many crashes happened form the frontal impact and this lead to many injuries and vehicles damage (Cheon et al., 1995; Donga, 2011). During all these frontal crashes, the first part that receives impact is the front bumper (Davoodi et al., 2012).This shows that for the front bumper, the energy absorption is really important because it is a main tool to damp the energy from crashes.

An investigation about how energy absorbed for the front bumper from different angle of impact is important because most severe crashes involves frontal impact. Moreover, all the crashes that happened had different location or direction of impact and every location has different energy absorption. With the different impact angle, the deflect angle also varies as each part of where the impact hit has different surface built. However, doing experiment for impact test can use a lot of cost and this can be avoided by using Finite Element Analysis (FEA) software such as ABAQUS.

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1.3 Objectives

Impact test simulation with different impact direction using FEA for bumper car.

1. To determine the energy absorbed with different angle of impact direction.
2. To correlate the energy absorbed with different impact direction.
3. To compare the results with previous studies.

1.4 Scope

This study focuses on studying the energy absorption for the front bumper at different impact angle of 0˚, 30˚, 45˚ using the Finite Element Analysis (FEA) with the specification of ABAQUS software. The velocity and force of impact are identified and not to change through the analysis. For the material and design of the bumper it is decided to be a metal bumper as the beginning stage before studying the real material with the design of a GEN 2 front bumper. During the analysis, the meshing used is the same optimum mesh that produce best result with acceptable time for each impact angle and the bumper model is modelled using the accurate scale of the manufactured bumper.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Bumper is one of necessary part in passenger vehicle as it is the main tool to damp the energy from crashes and also protect others of vehicle such as lamps, hood and cooling system especially the front bumper (Dange et al., 2015; Davoodi et al., 2011). In previous chapter, the studies about severity of type of crashes and bumper development history are brought up to show the importance of car bumper. However, in this chapter more studies will be referred to explain the details of car bumper system, crash test standard, impact mechanics and the effect of impact direction towards impact response. These are important things to be reviewed so that the energy absorption on front car bumper during frontal or even oblique impact.

2.2 Function of Bumper

Bumper is a protective layer that is designed to fit on the front and rear sides of the car to produce a shielding effect thus enabling certain range of safety from collision. (Moona, Yadav, Singh, & City, 2015). The common material that used to make bumpers are steel, aluminium, or plastic (Jamal, 2009; Moona et al., 2015).

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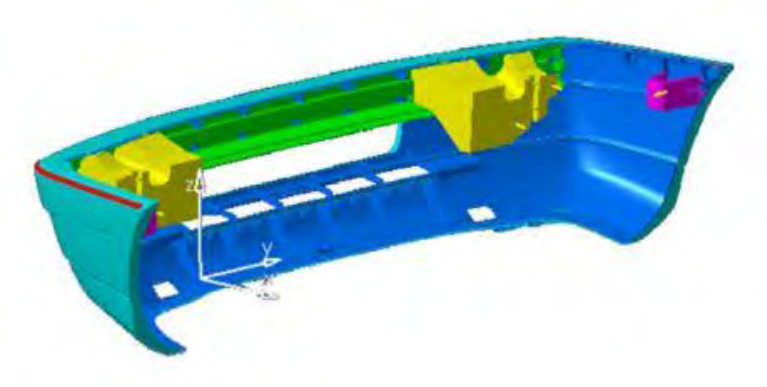

Figure 2.1: Bumper systems components (Davoodi et al., 2011)

Passive safety car system is the physical system that shield the passengers during collision such as front and rear car bumpers that can absorb impact energy (Calienciug, 2012). The main purpose of bumper is the absorption of impact energy to reduce the damage which can affect the car, passengers and even pedestrian. (Bohra & Pawar, 2014; Calienciug, 2012; Davoodi, Sapuan, & Yunus, 2008; Marzbanrad, Alijanpour, & Kiasat, 2009; Moona et al., 2015). Bumper reduces the damages of collision with other cars and objects due to their large deformation zones by deforming itself and absorb the force (kinetic energy) during a collision (Kleisner & Zemˇ, 2009)

However, bumper shows it most importance in absorption of impact energy during low speed collision and prevent serious damages (Belingardi, Beyene, & Koricho, 2013; Beyene, Koricho, Belingardi, & Martorana, 2014; Jamal, 2009). This is because, bumper can only absorb impact energy efficiently until 5 mile/h collision regulation and impact energy is not absorbed enough at higher speed collision (Cheon et al., 1995). In addition, bumper also intended to protect and shield the nearby component of car such the hood, trunk, grille, fuel tank, exhaust and this also includes the engine and rear part (Jamal, 2009; Moona et al., 2015)

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2.3 Bumper Systems

The whole frontal bumper system consists the following main parts, a fascia, energy absorber and bumper beam (Davoodi et al., 2011; Kleisner & Zemˇ, 2009). There are important factors that an engineer or designer must put in thought when selecting a bumper system. The most crucial factor is the ability of the bumper system to absorb enough energy (Steel Market Development Institute, 2013). Figure 2.1 shows the diagram for types of bumper systems.

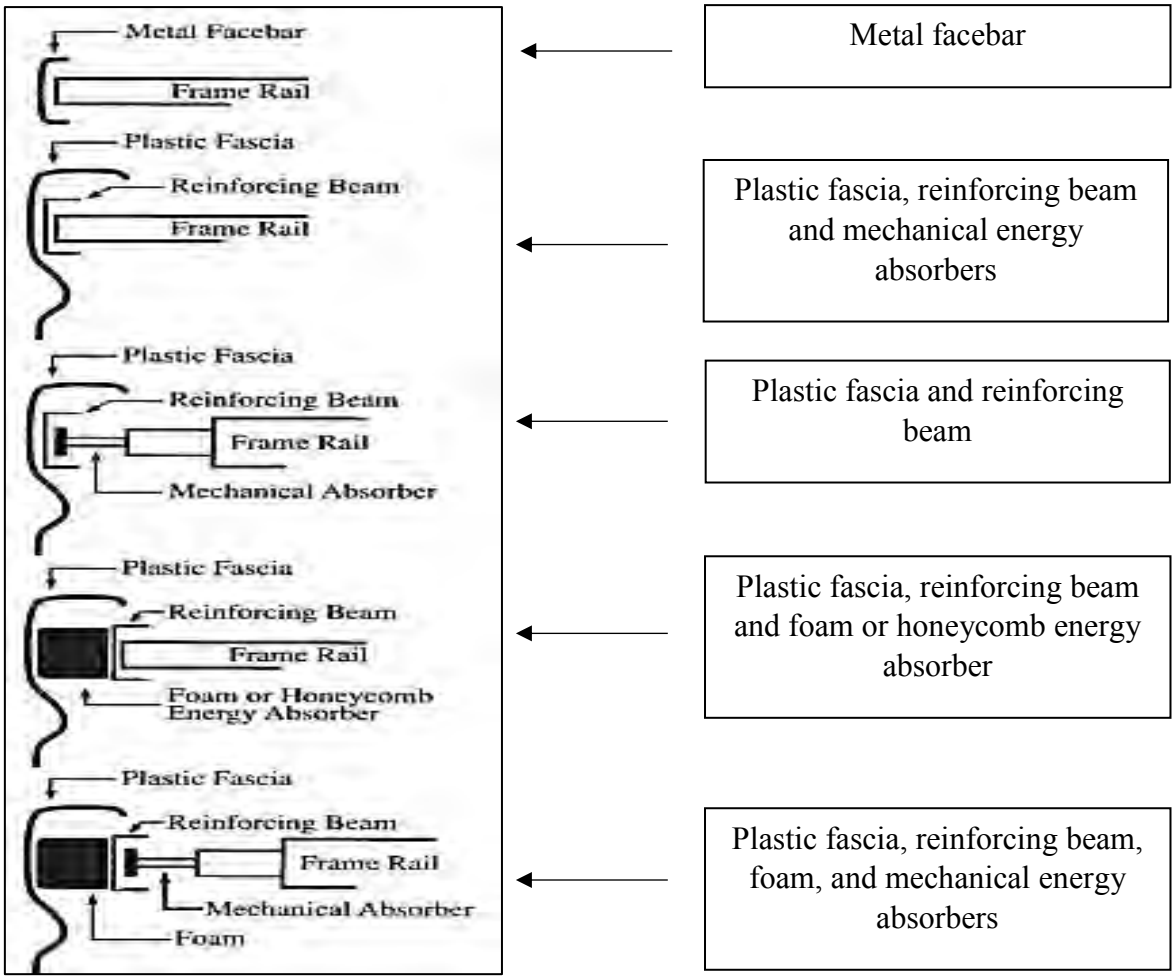

Figure 2.2: Diagram for types of bumper system (Steel Market Development Institute, 2013)

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